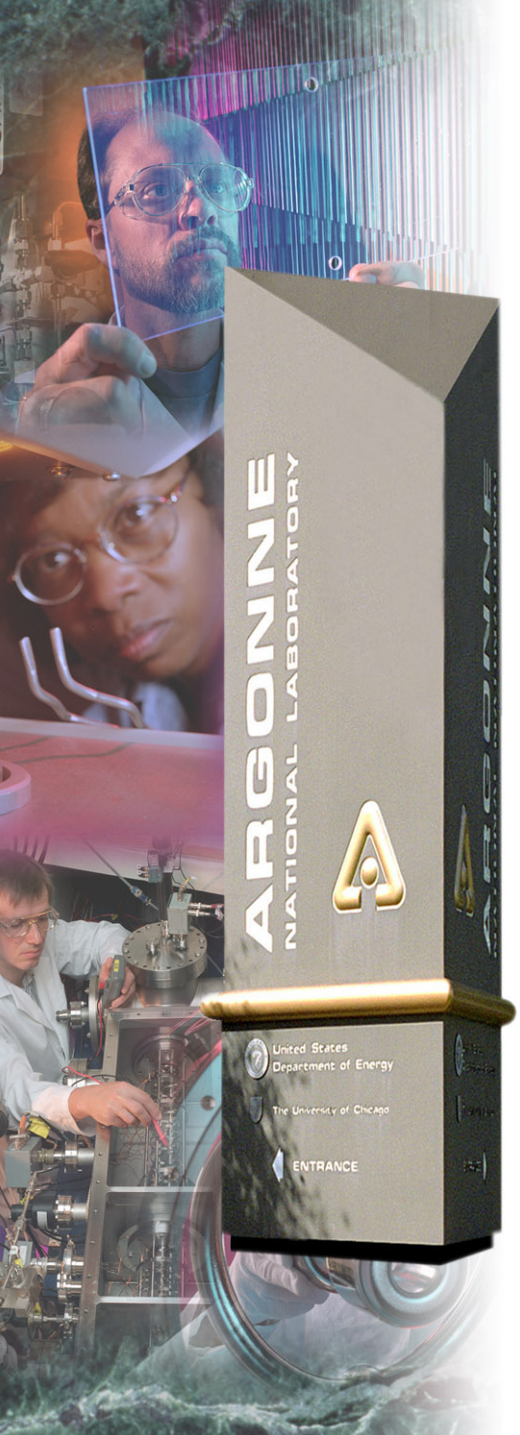

Digitizing Beam Position Limits Detector Training

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Purpose of DBPLD

- **The Beam Position Limits Detector (BPLD) is designed to protect the Advanced Photon Source (APS) storage ring in the event of beam mis-steering.**
  - This is done by sampling the beam position both upstream and downstream of each insertion device and comparing this measurement against a fixed limit. If the limit is exceeded a 1MHZ heartbeat signal is removed signaling the Machine Protection System (MPS) of the violation. There is one BPLD for each installed insertion device.

❖ **The original BPLD system has been decommissioned therefore the interchangeable use of the terms BPLD and DBPLD should not confuse anyone.**

General Specifications

- **Must dump beam in < 1ms of detecting mis-steered beam**
- **Horizontal Limit: ± 2.25mm* around BPM offset**
- **Vertical Limit: ± 1.00mm* around BPM offset**

- **P0 & P1 BPMs**

DBPLD Features

- **Four channels (BPMs) per board**
- **Two 8-bit digitizers per BPM (X and Y)**
- **Monitors BPM status (via sync signal)**
- **Monitors presence of stored beam (via AGC signal)**
- **Monitors status of insertion device gap status in fail safe manner**
  - If cable is broken or unplugged, the DBPLD interprets this as the gaps closed

Design Overview

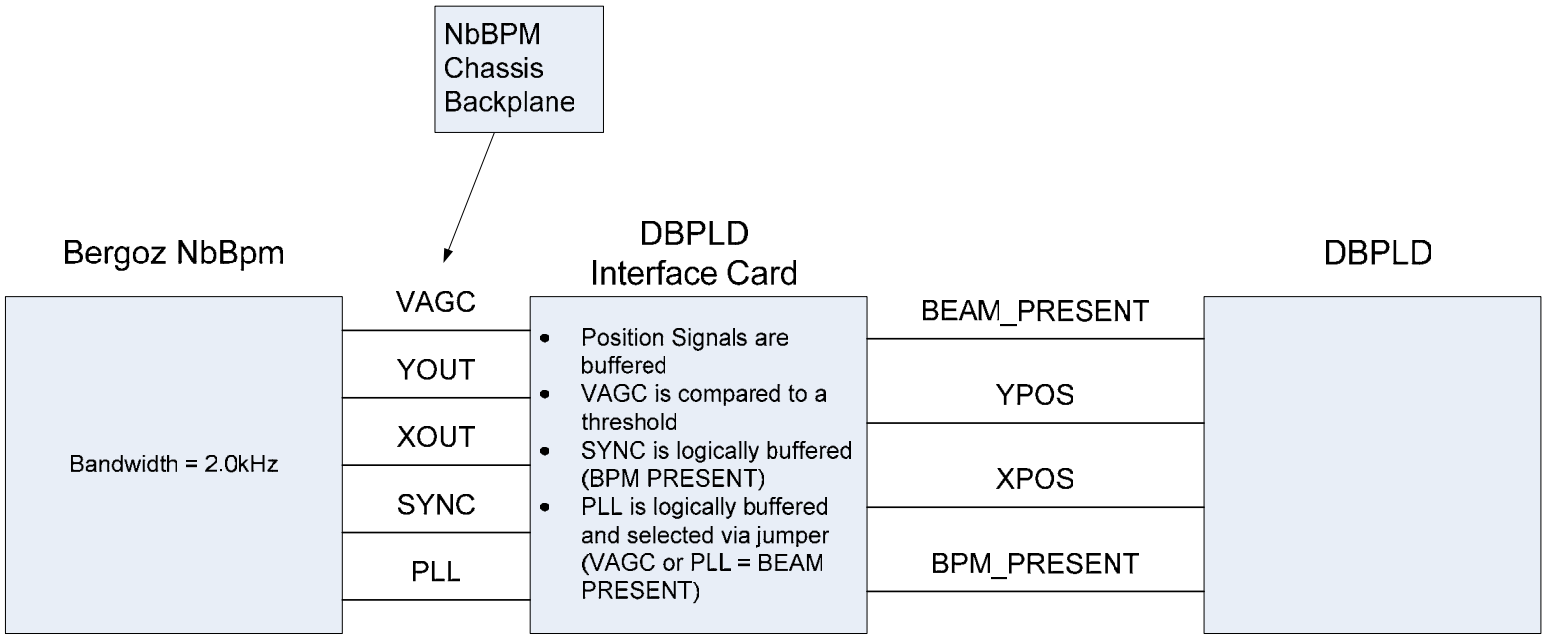
- **Three major components comprise the DBPLD system**
  - Bergoz narrowband BPMs connected to either P0 or P1 buttons
    - *300kHz IF bandwidth*
    - *8kHz sampling (four buttons)*
    - *300 – 400μs step response*
  - DBPLD Interface card residing in the narrowband BPM chassis
    - *Buffers position signals and **sync** signal*
    - *Compares AGC to fixed threshold for **Beam Present*** signal
  - DBPLD VME card
    - *Digitizes position signals*
    - *Compares digitized position signals to independent trip limits*
      - Four separate trip limits per channel
    - *Provides 1MHz heartbeat signal to MPS system*

System Physical Layout

The physical layout of the DBPLD system can be confusing.

- **The VME board resides in the BPM ioc**
- **Each VME board monitors 4 channels**
  - 1 channel consists of 1 BPM, 1 gap switch and 1 heartbeat signal
- **To provide protection for an insertion device two channels are required**
  - One channel for each end of the insertion device

1 Channel Signal Block Diagram



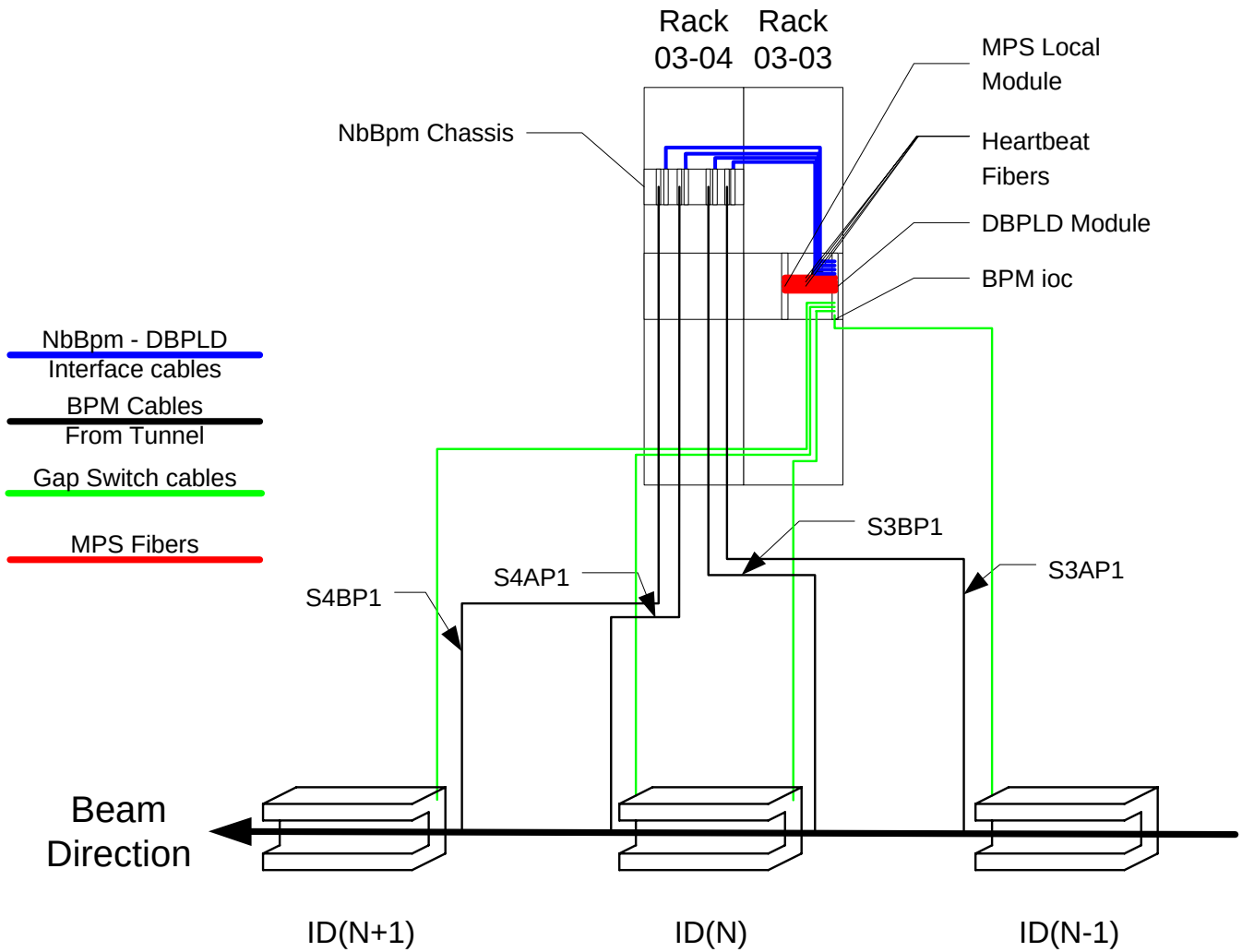
System Physical Layout

The 4 channels are assigned as follows:

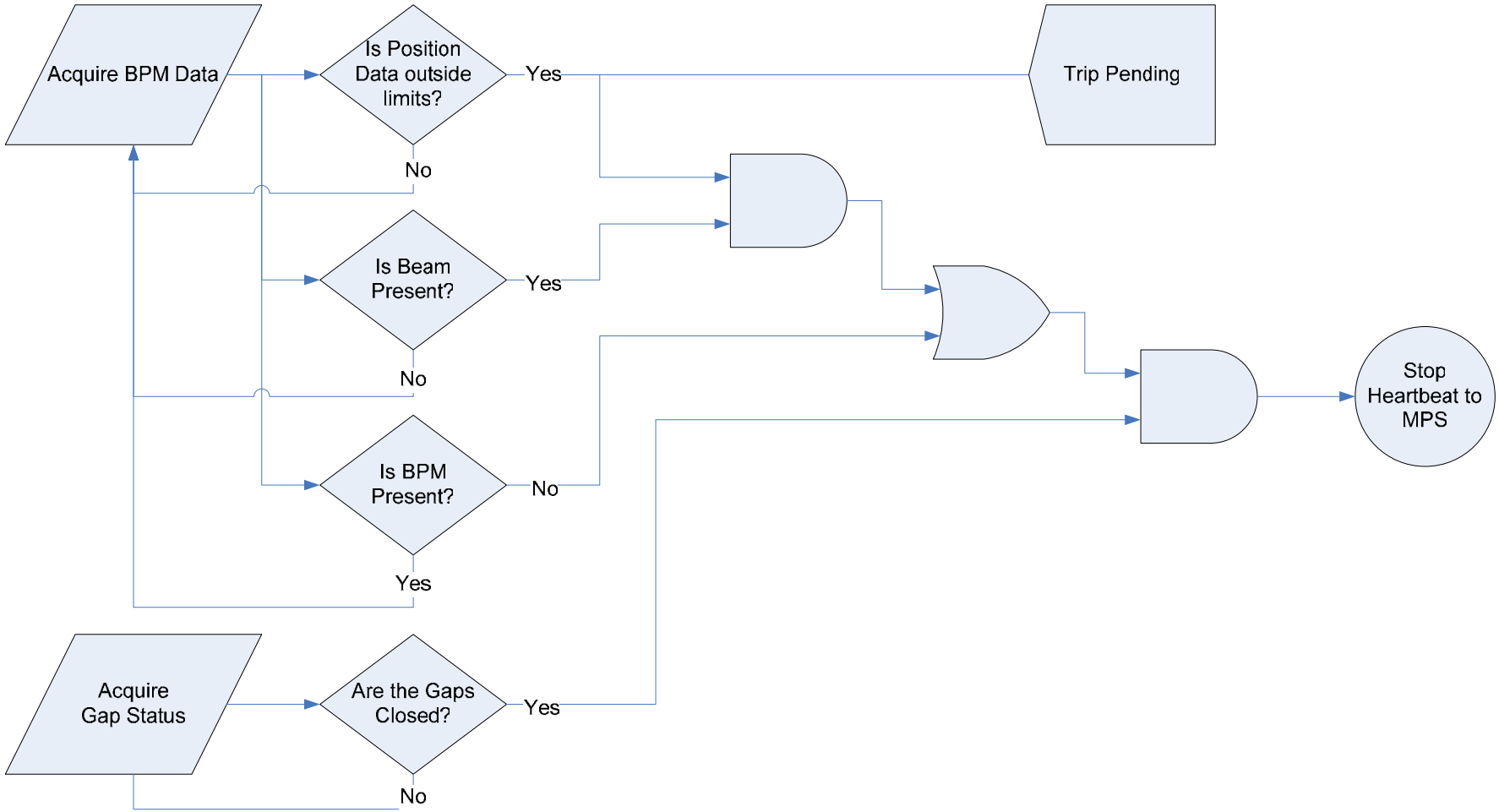
- Channel 0: ID #(N - 1) downstream end
- Channel 1: ID #(N) upstream end
- Channel 2: ID #(N) downstream end
- Channel 3: ID #(N + 1) upstream end

- **Example: (VME board in iocs3bpm)**
  - Channel 0: ID2 downstream
  - Channel 1: ID3 upstream
  - Channel 2: ID3 downstream
  - Channel 3: ID3 upstream

Cabling Diagram For 1 DBPLD Card



Decision Flow Diagram



Trip Logic Decision Tree

Interrupt the heartbeat to the MPS system if…

- **The ID gaps are closed AND the BPM is NOT present**

  OR

- **The ID gaps are closed AND beam is present AND beam is outside the trip limits**

- **Trip pending occurs if the beam signal is outside the trip limits**
  - There are four trip pending flags per channel
    - *Two horizontal flags and two vertical flags*
  - i.e. Horizontal reading > upper trip limit or
    Horizontal reading < lower trip limit or
    Vertical reading > upper trip limit or
    Vertical reading < lower trip limit

System Validation

- **Selected BPLD positions are validated during each startup period.**
- **The criteria for selecting which BPLDs will be validated are based, in part, on whether or not any work was done at that location.**
  - For instance, an insertion device was changed, a BPLD circuit board was changed, or the corresponding BPM was serviced. It is the responsibility of representatives of the Beamline Operations group and the Diagnostics group to notify the Operations group of any work performed which may require BPLD validation. The operations group also randomly selects a few BPLD locations to validate during each startup period such that all BPLD locations are validated at least once each year.

System Validation

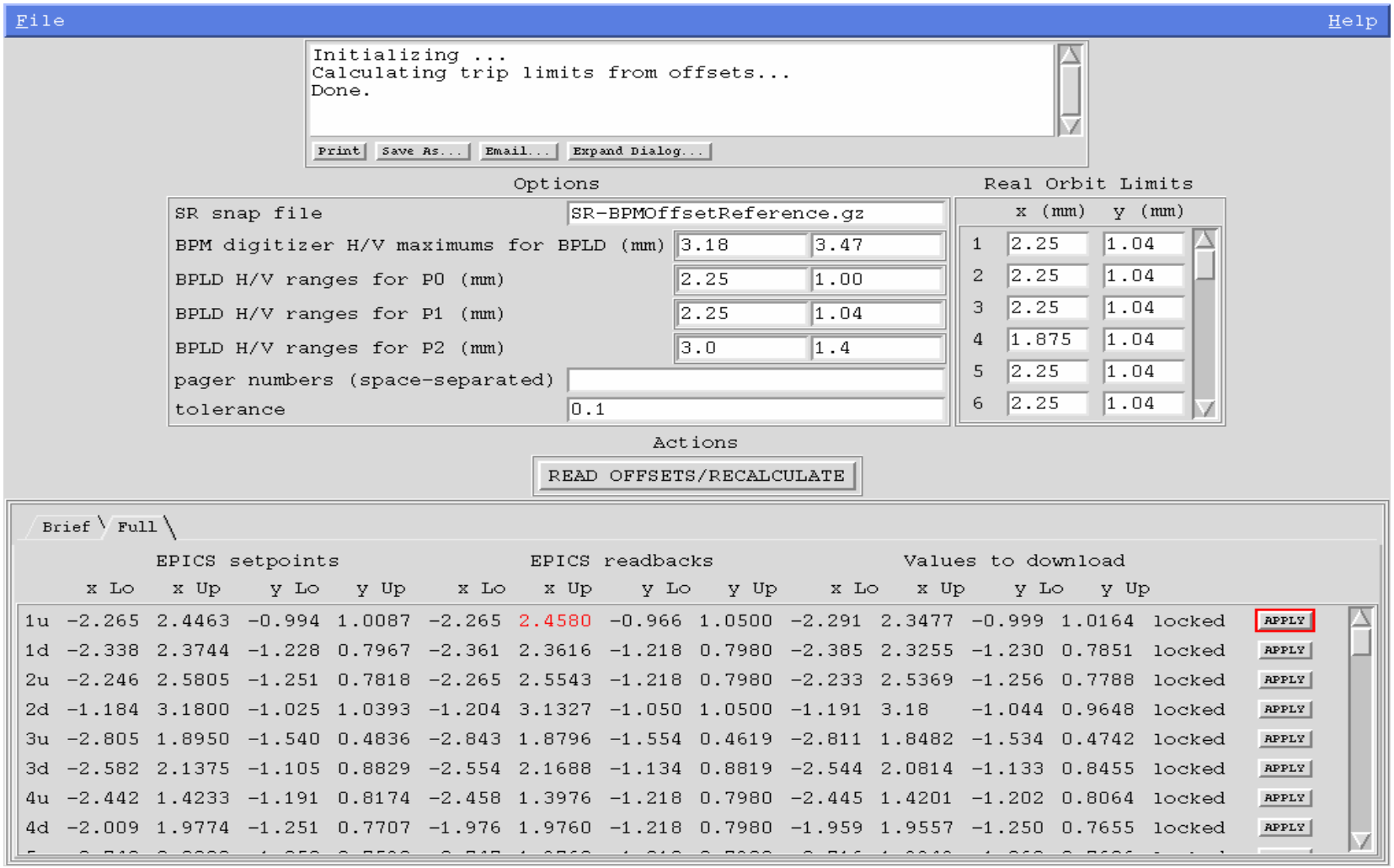
There are two slightly different types of validation

- **One is simply to verify that a "trip pending" event occurs by sequentially steering the beam towards all four trip limits.**
- **The other is to verify that the BPLD system initiates an MPS trip. Both of these validations are performed with beam.**

Software Tools

- **BPLD Trip Limits Loading application**
  - This application is used by the operators and/or system manager to download the appropriate trip limits to the board
    - *An operator, or other appropriate individual, must physically walk to the individual iocs to turn a key allowing new limits to be loaded*
    - *These trip limits are calculated based on the bpm offset measurements*

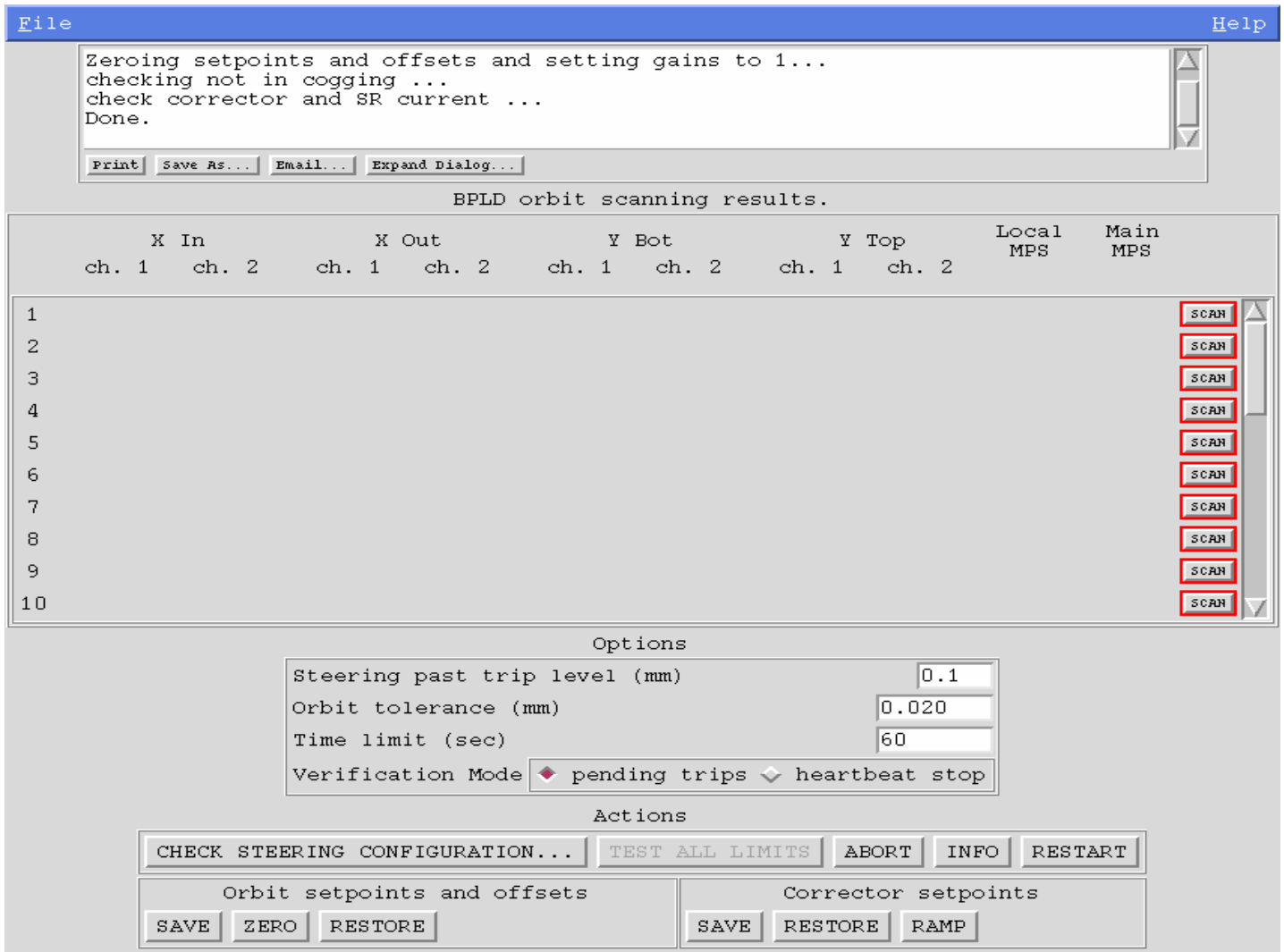
BPLD Trip Limits Loading Tk/Tcl Application



Software Tools

- **BPLD Verification application**
  - This application is used by the system manager to verify the system is operating properly
  - This application steers the beam in the appropriate directions to cause the DBPLD to trip in both planes (all four directions)

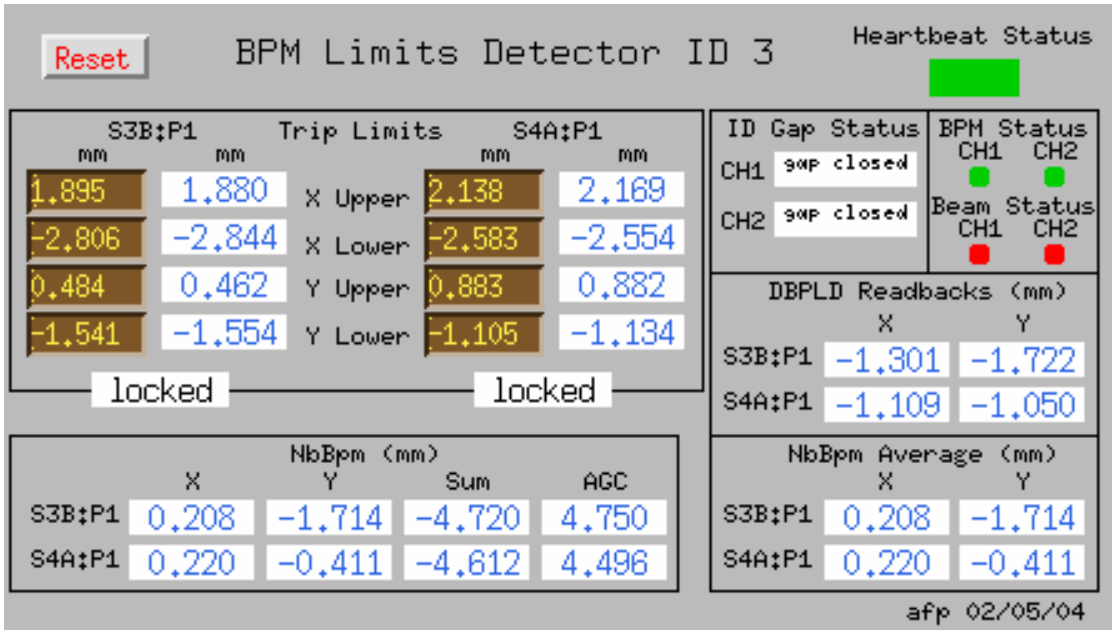
BPLD Verification Tk/Tcl Applications



MPS

- **The MPS system is “active” when stored beam is > 0.5mA**
  - The DBPLD system (thus the NbBpm system) must also be active and accurate at this quantity of stored beam
    - *Is this the case? Studies must be done to confirm this!*

BPLD MEDM Screen



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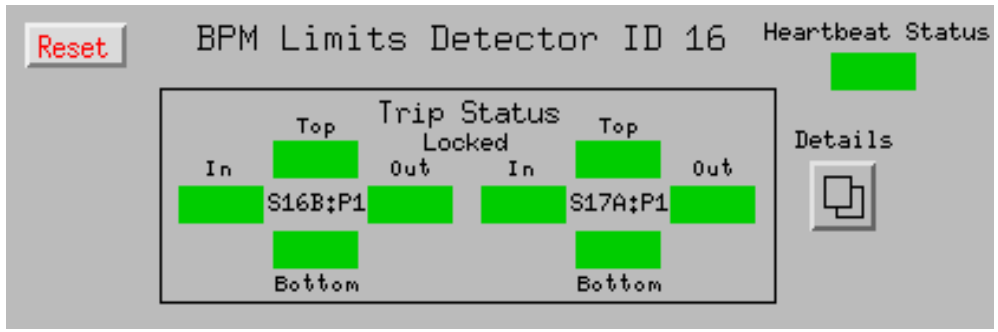
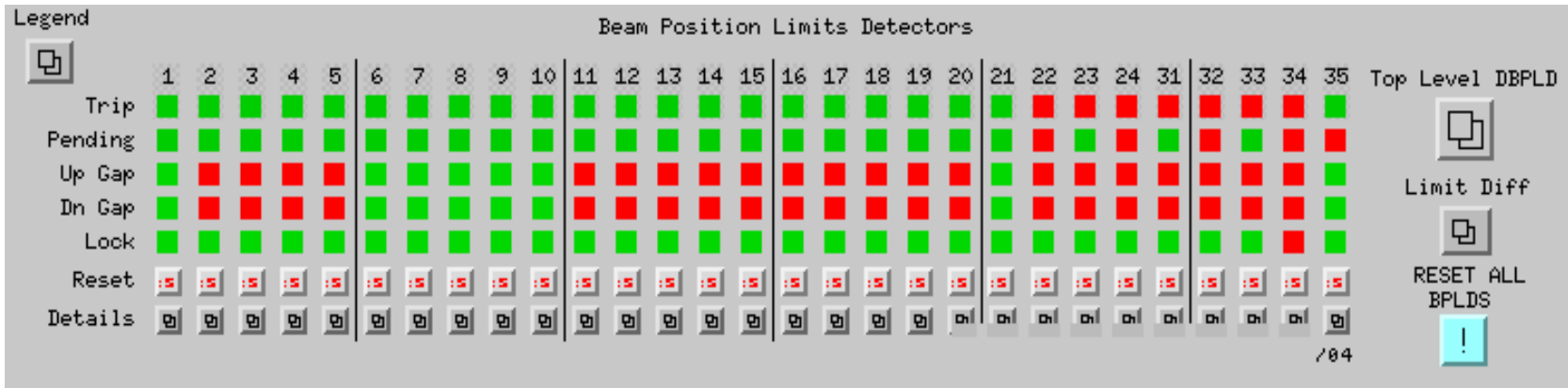


BPLD MEDM Screen



Reported Errors + Fixes

- **“Gap switch indication wrong”**
  - This has been reported a couple times. Each time the problem was in the tunnel (limit switch or actuator) and not a DBPLD fault. I will work with John Grimmer (XFD-XFE) to diagnose the problem. He is responsible for this hardware.

- **“Top level MEDM screen gap switch indication does not match the lower level MEDM screen gap indication”**
  - This problem was noticed several days ago during startup testing by John Grimmer. The process variables are different because of legacy issues. The problem turned out to be a “Z-line” power strip was turned off for a BPM VXI crate causing the ioc to have suspended tasks.

DBPLD Do's and Don'ts

- **Don't do touch ANY hardware during user runs**
  - Stored beam could be lost!!!
- **Don't power cycle a BPM ioc with stored beam (gaps closed)**
  - Stored beam will be lost!!!
- **Do make sure the BPM offsets are up to date**
  - BPM offset measurements must be done whenever BPM hardware is changed
- **Do make sure the proper limits are loaded**
  - Calculations are based on the BPM Offset Reference file
- **Do validate position and heartbeat whenever DBPLD hardware is "worked on"**

Procedures

- **Procedure # 31050402-00024 – Operational Procedure for Changing Limits on the Beam Position Limits Detectors**
- **Procedure 31050402-00025 – Beam Position Limits Detector Validation Procedure**

The diagnostics web page dedicated to this system will soon be updated with better information. It is currently located at:

www.aps4.anl.gov/diagnostics/Interlocks/dbpld/dbpldtop1.html

Conclusion

- **The Beam Position Limits Detector (BPLD) is designed to protect the Advanced Photon Source (APS) storage ring in the event of beam mis-steering**
- **There is one DBPLD for each installed insertion device**
- **Each DBPLD VME board monitors 4 channels**
- **The DBPLD system must be validated whenever work is performed on any component of the system**
- **Many DBPLD positions are validated during each startup period selected so that each position is validated at least once each year**

Questions??